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(54) **NAVIGATION SYSTEM**

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CPC ***G01C 21/34*** (2013.01); ***G01C 21/367*** (2013.01)

(58) **Field of Classification Search**
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USPC 701/428
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2013/0166209 A1* 6/2013 Pollington G06Q 10/06 701/540
2016/0047660 A1* 2/2016 Fausten B60W 50/12 701/25
2016/0082978 A1* 3/2016 Ozaki G01C 21/34 701/58
2016/0109551 A1* 4/2016 Faragher G01S 5/0263 701/23
2016/0138925 A1* 5/2016 Takahashi B60L 11/1809 701/533
2016/0155310 A1* 6/2016 Joao G08B 21/02 340/573.1
2016/0209842 A1* 7/2016 Thakur G01C 21/34 701/25
2016/0209843 A1* 7/2016 Meuleau G05D 1/0088 701/25
2016/0209845 A1* 7/2016 Kojo G05D 1/0225 701/25

FOREIGN PATENT DOCUMENTS

JP 2004-245609 A 9/2004
JP 2005-276070 A 10/2005
JP 2007-170927 A 7/2007
JP 2007-322304 A 12/2007
JP 2008-102024 A 5/2008
JP 2009-63422 A 3/2009

OTHER PUBLICATIONS

Communication dated Aug. 17, 2016 from the European Patent Office in counterpart Application No. 16153448.2.

* cited by examiner

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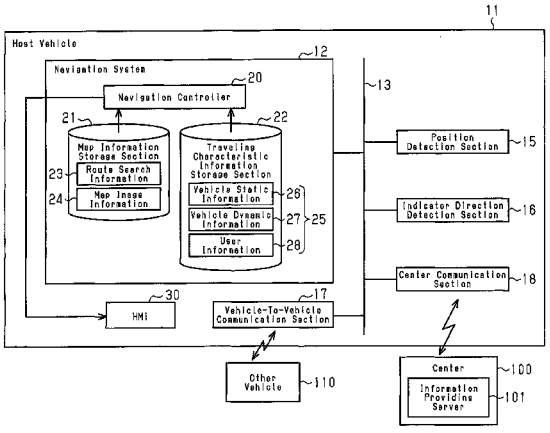
(57) **ABSTRACT**

A required time calculator calculates a virtual required time period when a first movable body is assumed to travel a second route different from a first route the first movable body actually travels and arrive at a second point. The required time calculator preferentially acquires position information from a second movable body having information indicating a movement characteristic similar to information indicating the movement characteristic of the first movable body from among one or more of second movable bodies. The required time calculator calculates the virtual required time period using the acquired position information.

5 Claims, 8 Drawing Sheets



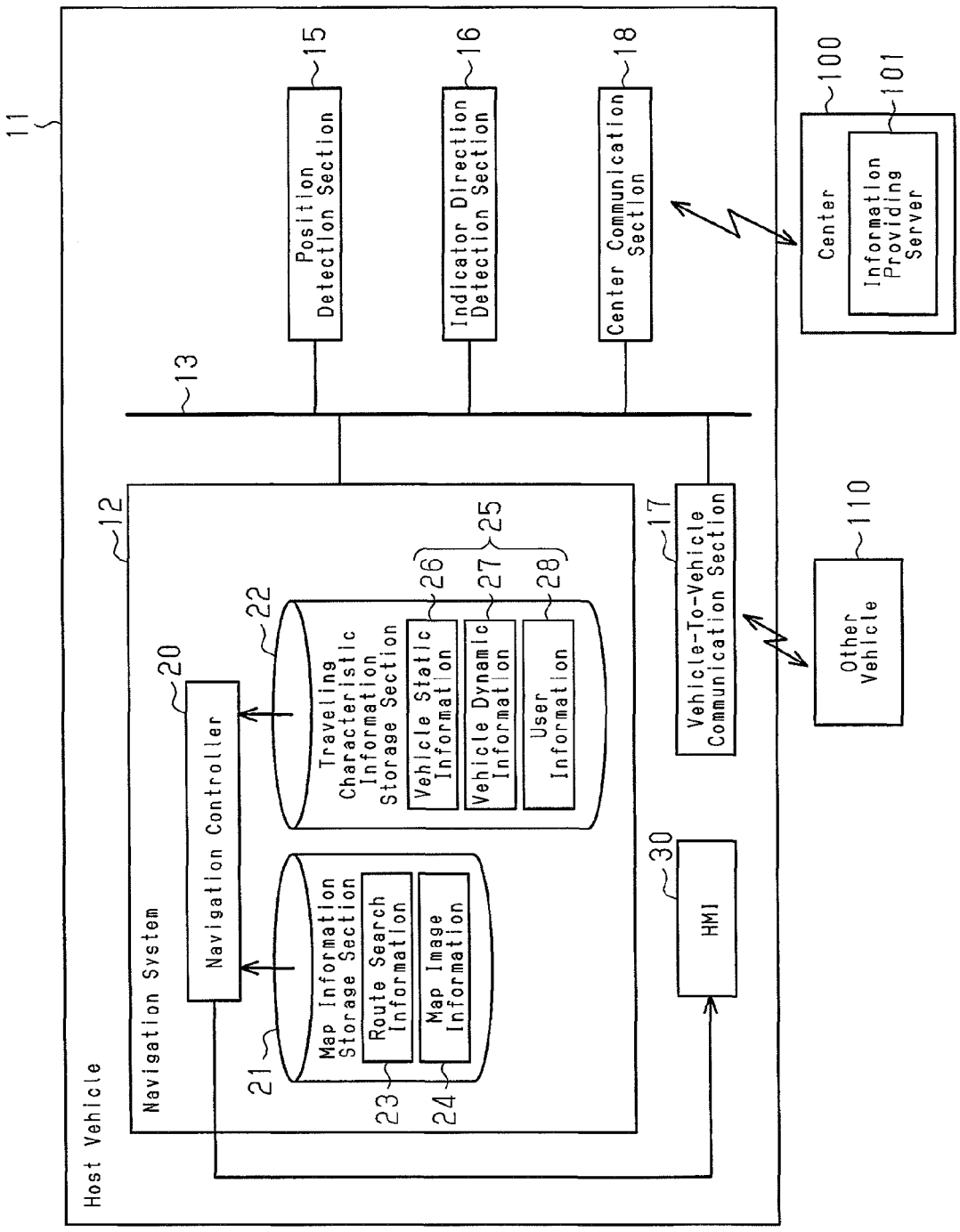

11
Host Vehicle
Navigation System
12
Navigation Controller
20
Map Information Storage Section
21
Route Search Information
23
Map Image Information
24
Traveling Characteristic Information Storage Section
22
25
Vehicle Static Information
26
Vehicle Dynamic Information
27
User Information
28
13
Position Detection Section
15
Indicator Direction Detection Section
16
Center Communication Section
18
HMI
30
Vehicle-To-Vehicle Communication Section
17
Center
100
Information Providing Server
101
Other Vehicle
110

Fig.1

Fig.2

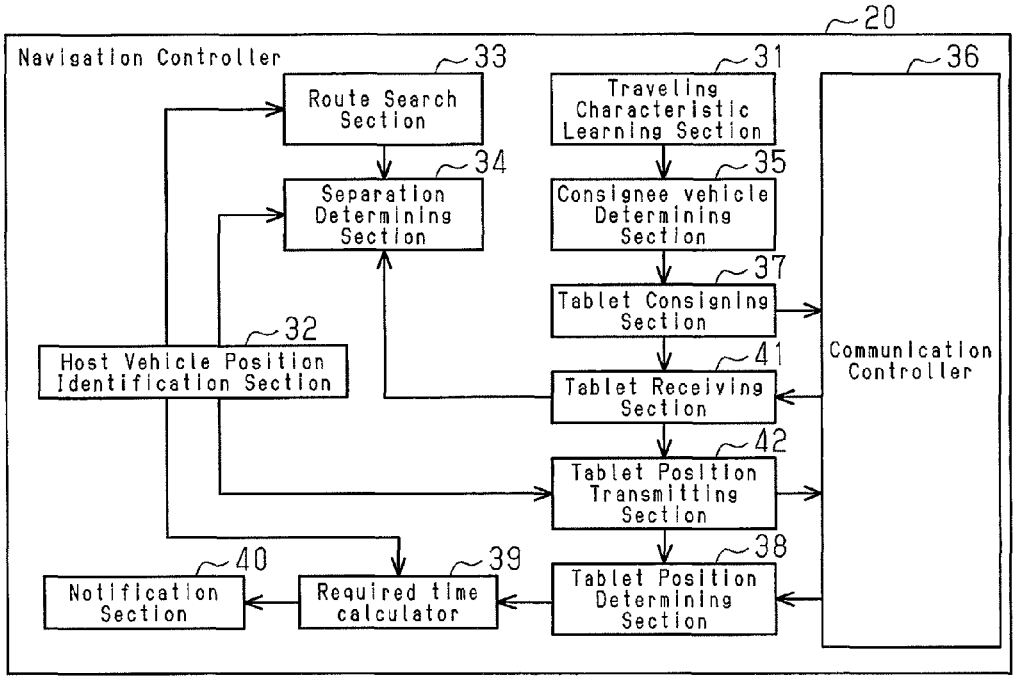


Fig.3

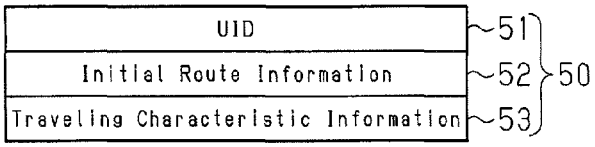


Fig.4

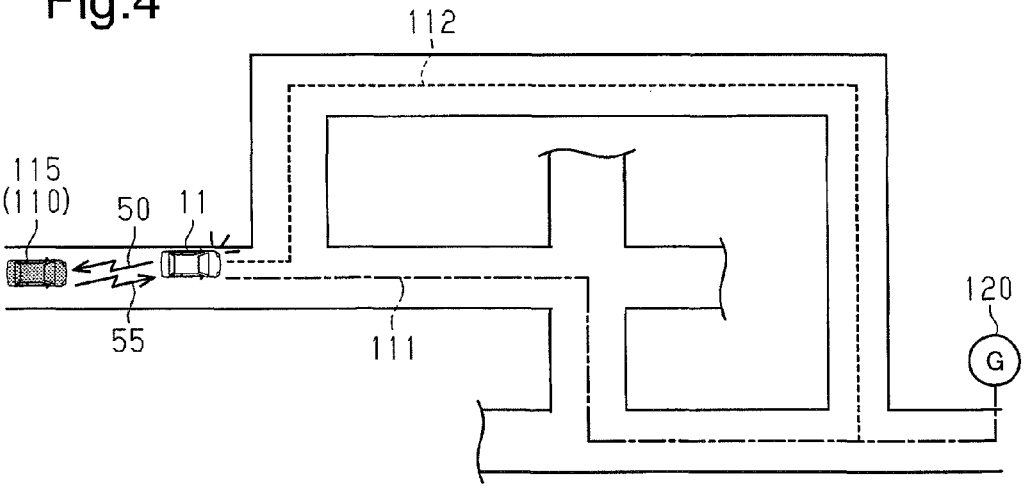


Fig.5

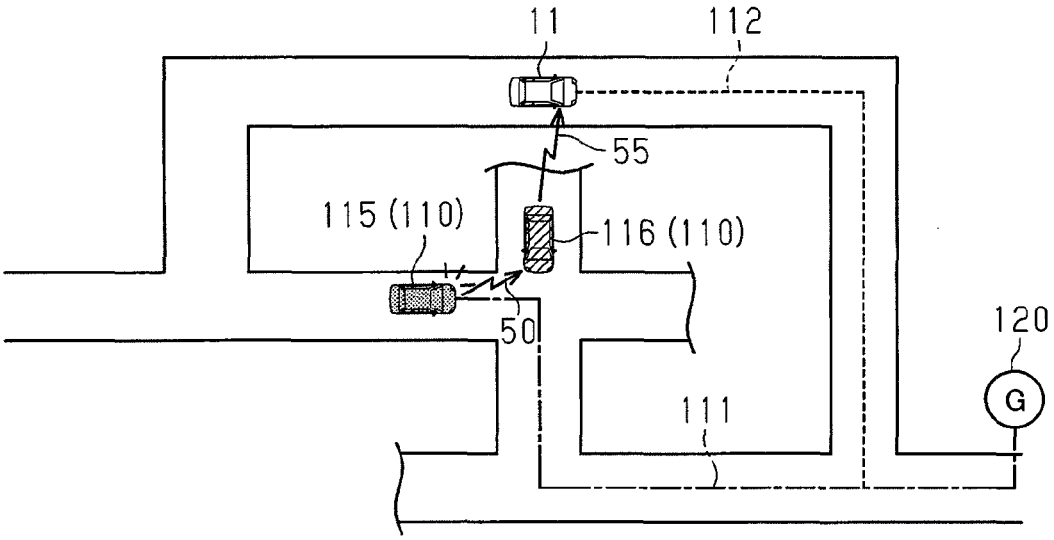


Fig.6

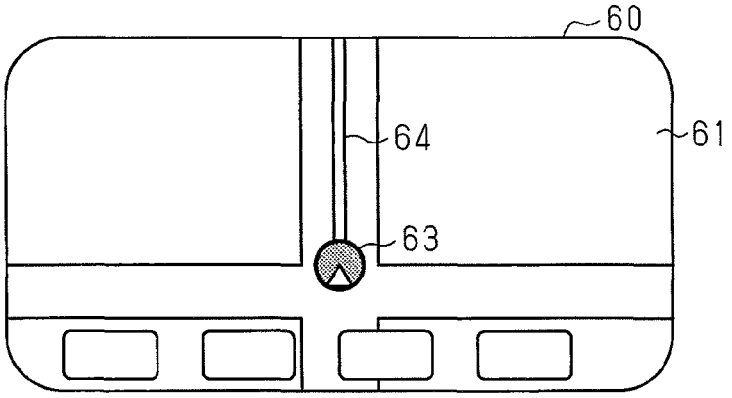


Fig.7

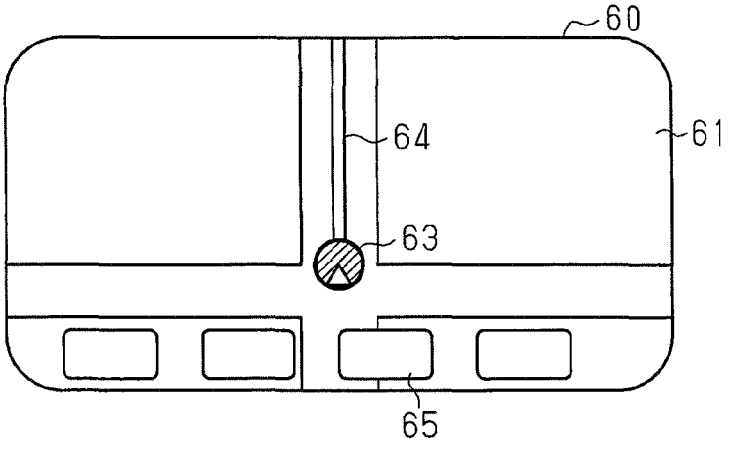


Fig.8

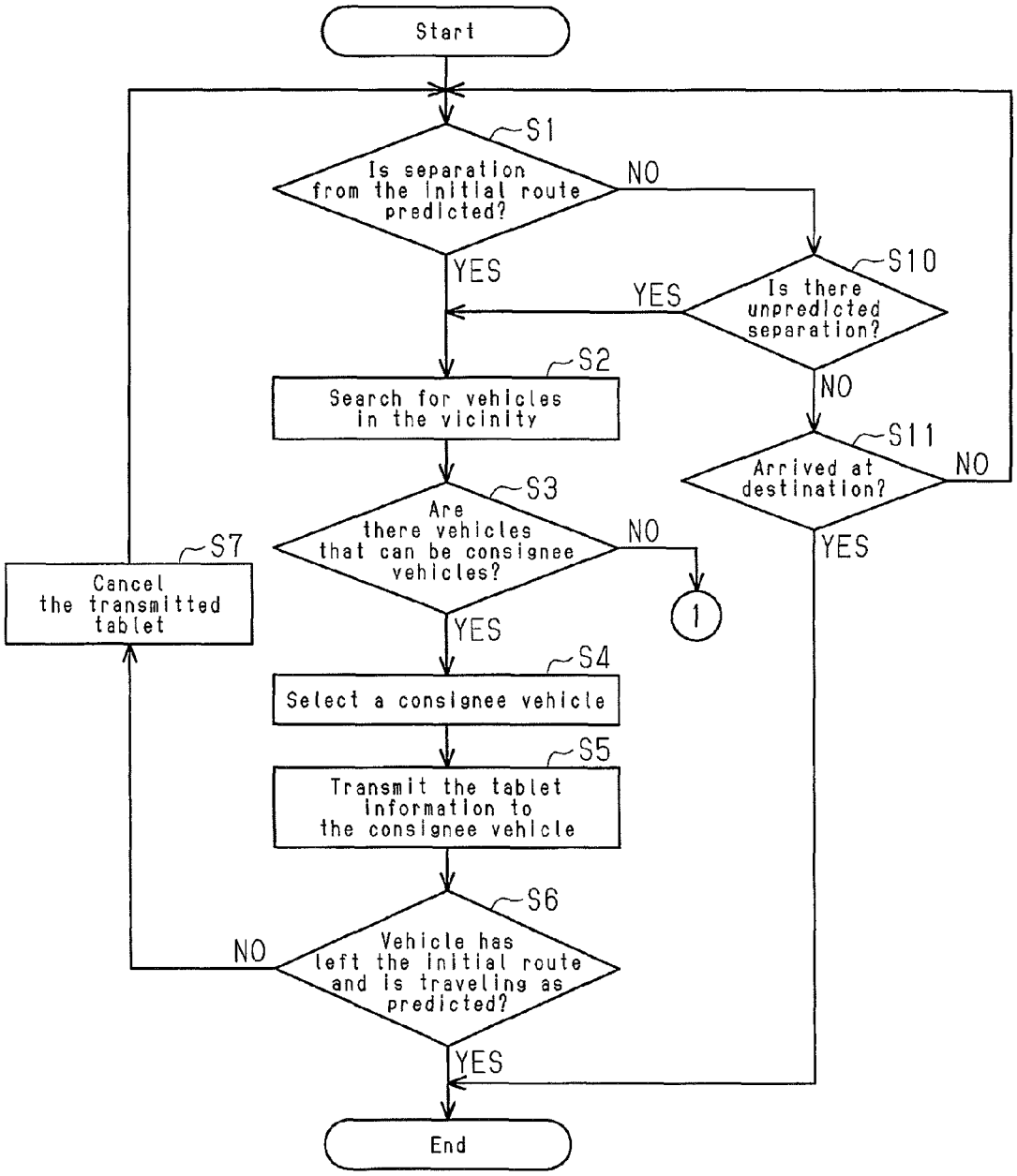

Start
S1
Is separation from the initial route predicted?
NO
YES
S10
Is there unpredicted separation?
YES
NO
S2
Search for vehicles in the vicinity
S11
Arrived at destination?
NO
YES
S3
Are there vehicles that can be consignee vehicles?
NO
YES
1
S7
Cancel the transmitted tablet
S4
Select a consignee vehicle
S5
Transmit the tablet information to the consignee vehicle
S6
Vehicle has left the initial route and is traveling as predicted?
NO
YES
End

Fig.9

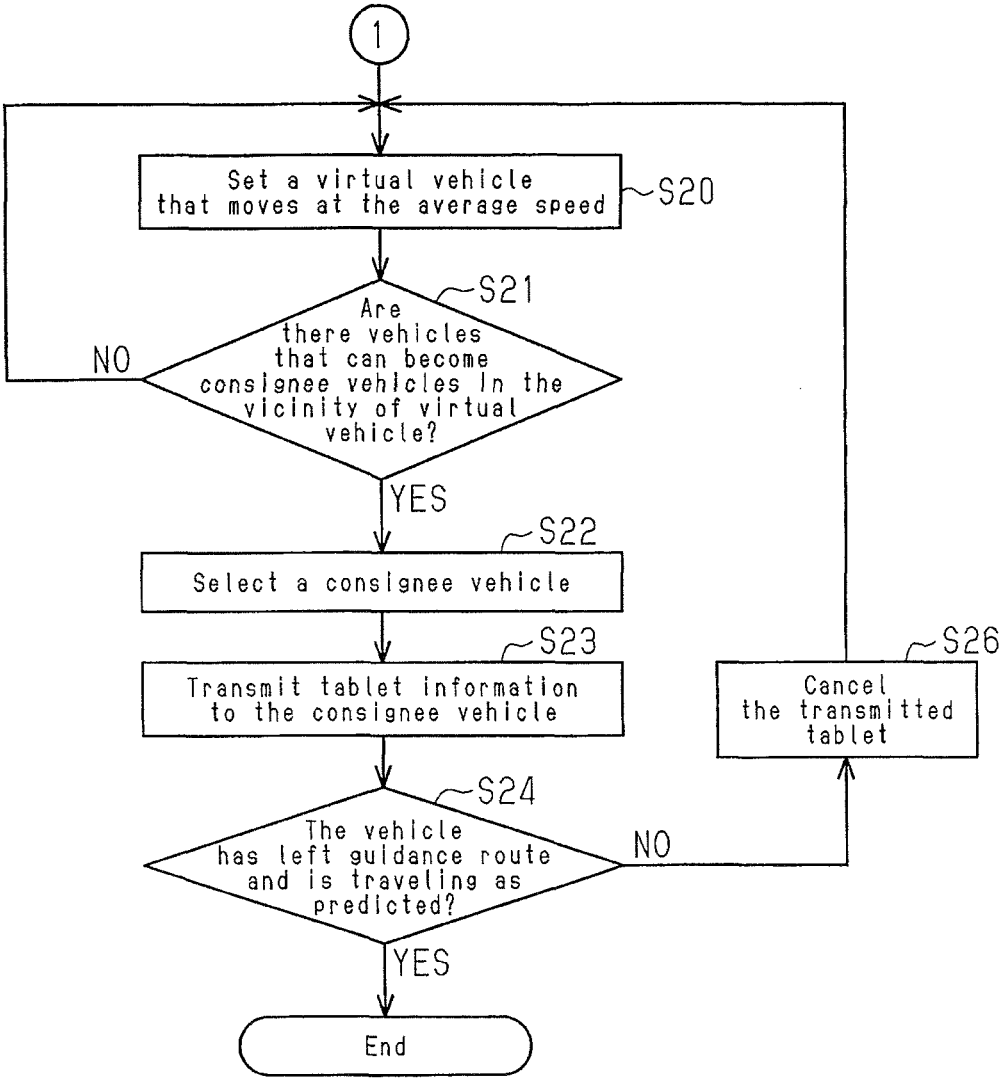

1
Set a virtual vehicle that moves at the average speed
S20
S21
Are there vehicles that can become consignee vehicles in the vicinity of virtual vehicle?
NO
YES
S22
Select a consignee vehicle
S23
Transmit tablet information to the consignee vehicle
S24
The vehicle has left guidance route and is traveling as predicted?
NO
YES
S26
Cancel the transmitted tablet
End

Fig.10

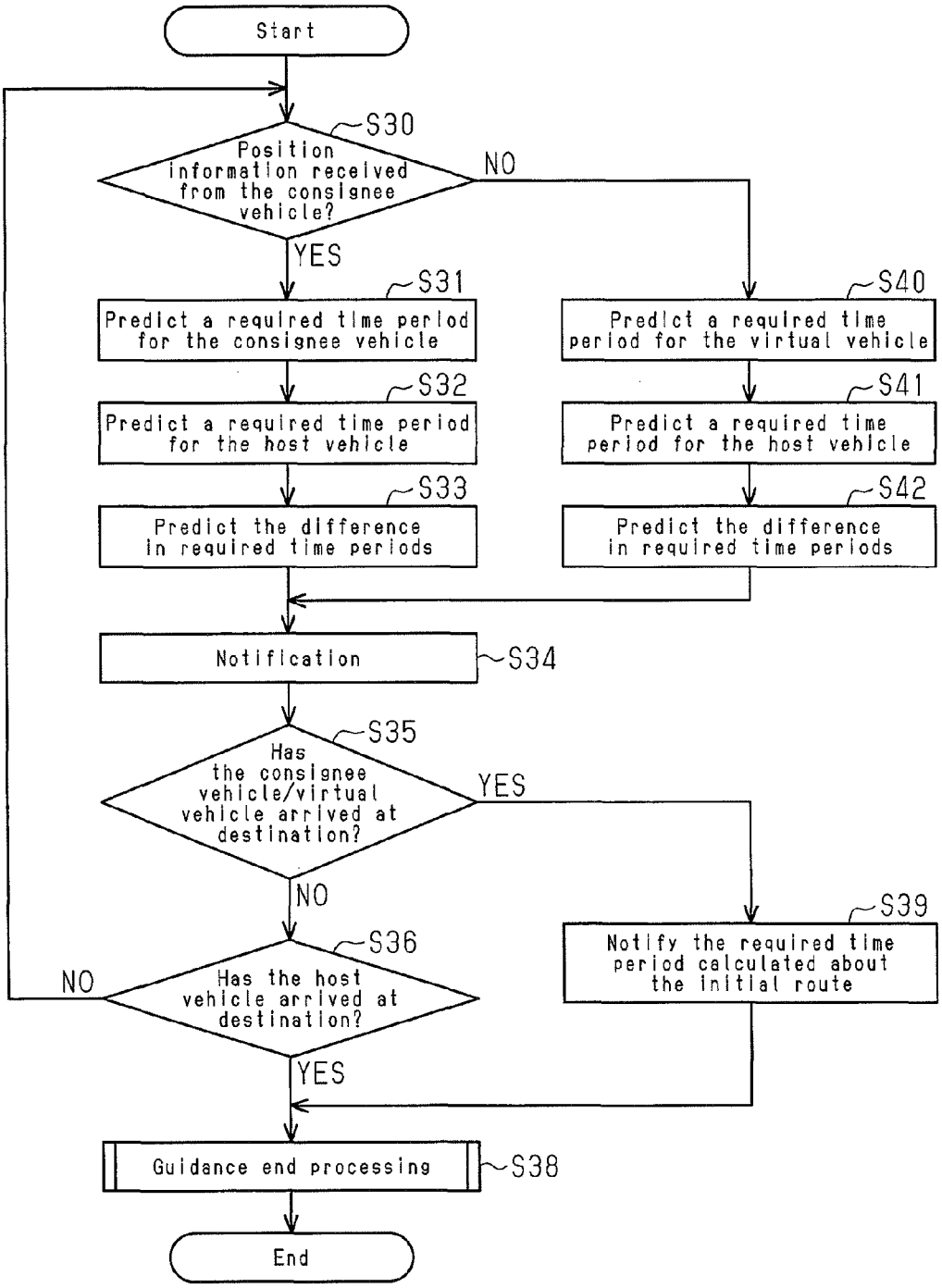

Start
S30
Position information received from the consignee vehicle?
NO
YES
S31
Predict a required time period for the consignee vehicle
S32
Predict a required time period for the host vehicle
S33
Predict the difference in required time periods
S40
Predict a required time period for the virtual vehicle
S41
Predict a required time period for the host vehicle
S42
Predict the difference in required time periods
Notification
S34
S35
Has the consignee vehicle/virtual vehicle arrived at destination?
YES
NO
S36
Has the host vehicle arrived at destination?
NO
YES
S39
Notify the required time period calculated about the initial route
Guidance end processing
S38
End

Fig.11

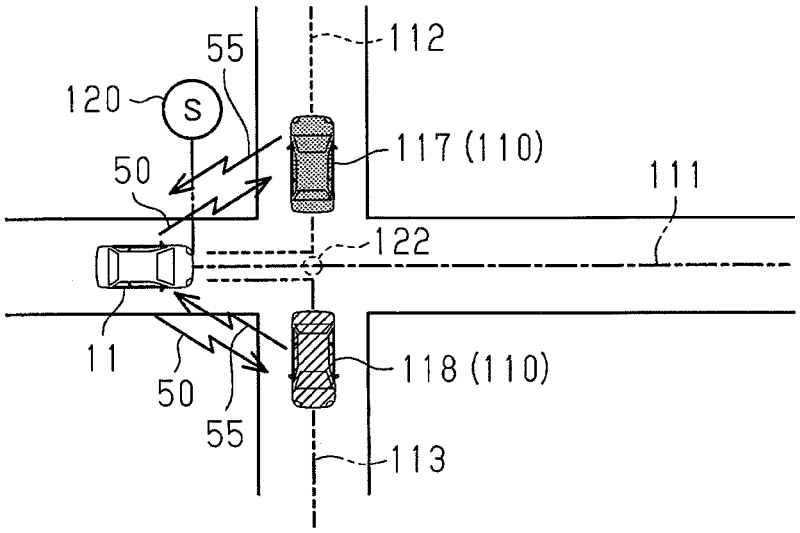

55
112
120
S
117 (110)
50
111
122
11
50
55
118 (110)
113

Fig.12

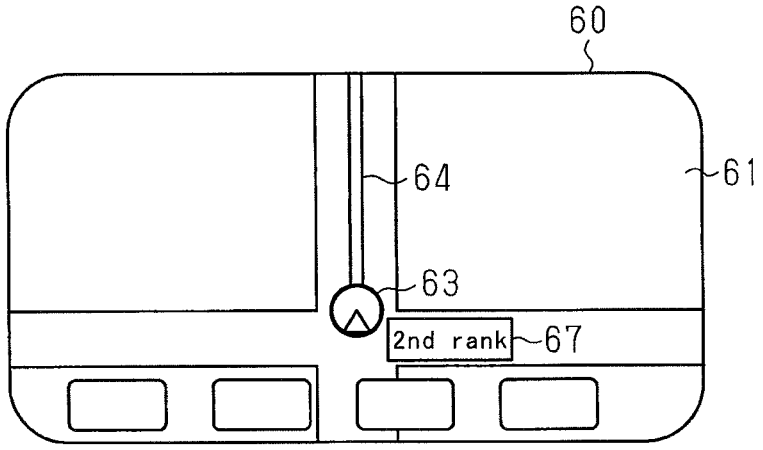

60
64
61
63
2nd rank
67

Fig.13

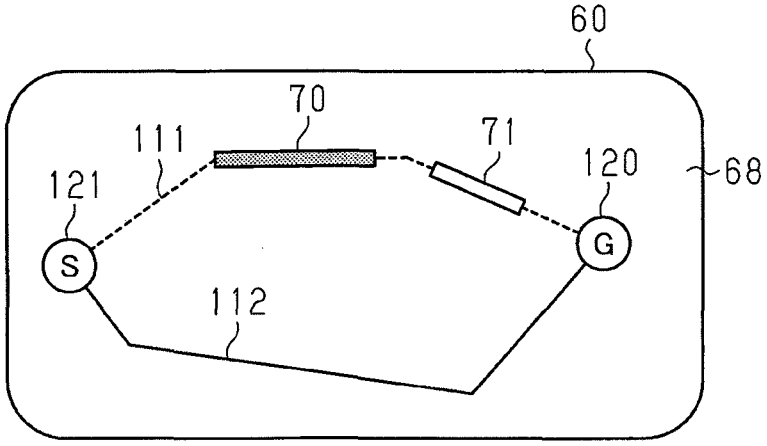
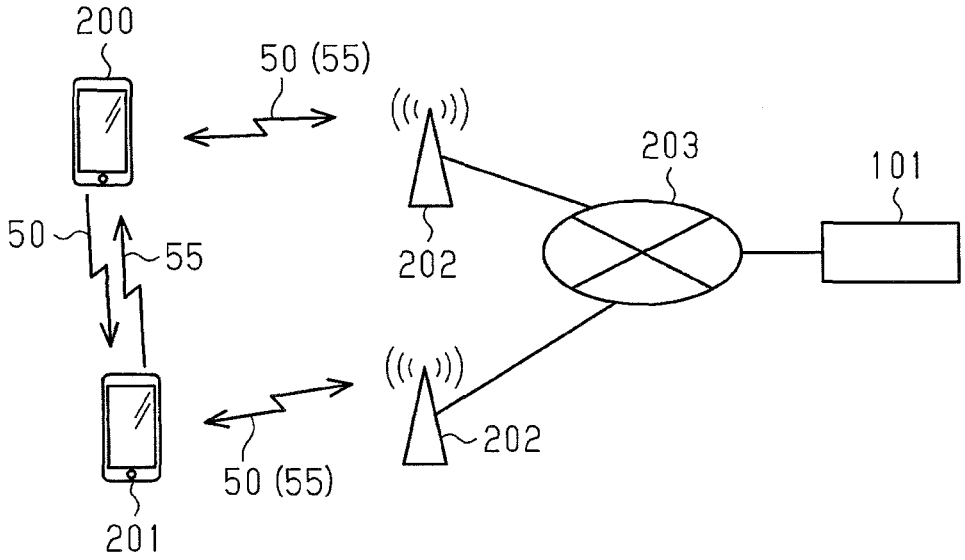

60
70
111
71
120
68
121
S
G
112

Fig.14


200
50 (55)
203
101
50
55
202
202
50 (55)
201

NAVIGATION SYSTEM

BACKGROUND OF THE DISCLOSURE

The present disclosure relates to a navigation system capable of estimating a time period required for a movable body to move between any given points. The navigation system is also capable of estimating a time period required for movement along a route different from that of the movable body.

As is generally known, navigation systems mounted on vehicles search for a route from a place of departure to a destination and provide guidance on the found route to users. However, conventionally, when a vehicle leaves an initial route guided by a navigation system and arrives at a destination via an alternative route, even if the user wants to compare required time periods when the vehicle leaves the initial route and arrives at the destination and when the vehicle arrives at the destination without leaving the initial route, the user has no way to make such a comparison.

In contrast, a system has been proposed that transmits an agent program to another vehicle traveling along a route different from the route of the host vehicle to set the other vehicle as a virtual vehicle (e.g., see Japanese Laid-Open Patent Publication No. 2004-245609). In this system, the virtual vehicle, which has received the agent program, transmits a traveling result to the vehicle that is the transmission source of the agent program though a function of the agent program. When the virtual vehicle, which has received the agent program, leaves the alternative route it is traveling, the virtual vehicle transfers the agent program to a third vehicle that is traveling the route. Thus, the third vehicle, which has received the agent program, is newly set as a virtual vehicle and transmits the traveling result to the host vehicle, which is the transmission source of the agent program.

According to the above-described system, even if a vehicle that is a virtual vehicle leaves the route to be compared, another vehicle traveling the route is set as a virtual vehicle. It is thus possible to calculate a required time period that reflects changing factors such as congestion and traffic control.

However, the vehicle that has received the agent program does not always display the same traveling performance as that of the host vehicle. Therefore, even when the time period required by the virtual vehicle is calculated using the traveling result of the vehicle that has received the agent program, it is difficult to bring the required time period calculated in this way closer to the required time period when the host vehicle actually travels along the alternative route. Such a problem is not limited to navigation systems mounted on vehicles or other movable bodies, but is generally common to navigation systems or the like incorporated in portable information terminals, for example.

It is an objective of the present invention to provide a navigation system capable of obtaining, even for a route along which a movable body does not actually move, results similar to results that would be obtained if the movable body actually moved along the route.

SUMMARY

In accordance with one aspect of the present disclosure, a navigation system capable of acquiring a first required time period and a second required time period is provided. The first required time period is a time period required for a first movable body to arrive at a second point from a first point via a first route and the second required time period is a time period required for a second movable body moving along a second route different from the first movable body to arrive at the second point from the first point. The navigation system includes a storage section, a movement characteristic information acquiring section, and a required time calculator. The storage section stores information indicating respective movement characteristics of the first movable body and the second movable body. The information is defined in advance and the movement characteristics are classified by one or more factors that affect an arrival time when the first movable body and the second movable body travel an identical route. The movement characteristic information acquiring section is configured to acquire the information indicating the movement characteristics of the first movable body and the information indicating the movement characteristics of the second movable body from the storage section. The required time calculator calculates a third required time period which is a virtually required time period when the first movable body is assumed to arrive at the second point after movement the second route, which is different from the first route, along which the first movable body actually has moved. The second movable body, which has passed through the first point as in the case of the first movable body, is one or more second movable bodies. The required time calculator is configured to preferentially acquire position information from the second movable body having the information indicating a movement characteristic similar to the information indicating the movement characteristic of the first movable body from among the one or more second movable bodies. The required time calculator is configured to calculate the third required time period using the acquired position information.

In the above-described configuration, position information is acquired preferentially from a second movable body having information indicating a movement characteristic similar to that of the first movable body from among one or more of second movable bodies that have passed through the first point in the same way as the first movable body. That is, this position information reflects the movement characteristic similar to that of the first movable body and also reflects the traffic situation or the like of the second route. Therefore, it is possible to obtain results similar to results that would be obtained if the first movable body actually moved along the second route, by calculating a time period required to reach the second point using this position information. Therefore, the user is allowed to determine the appropriateness of the route selected by the user through a comparison between the actual required time period to reach the second point via the first route and the required time period virtually calculated with respect to the second route.

As a comparative example, in order to compare the route along which the host vehicle actually has traveled with an alternative route, a system may be considered in which another vehicle in the vicinity of the host vehicle is set as a virtual vehicle and a required time period for the virtual vehicle to arrive at the destination is calculated. This type of system sets another vehicle traveling along an alternative route as a virtual vehicle, acquires the position of the virtual vehicle via wireless communication, and compares the required time period for the host vehicle and the required time period for the virtual vehicle using the acquired position. Thus, by acquiring data in real time from the other vehicle traveling along the alternative route in the same time period of day as that of the host vehicle, it is possible to make a comparison that reflects changing factors such as congestion, traffic control and the like.

However, the following problem occurs when collecting data by setting the virtual vehicle. That is, the other vehicle that is set as the virtual vehicle is not always directed to the same destination as that of the host vehicle. Therefore, when the virtual vehicle leaves the route directed to the destination, it is not possible to calculate the required time period although it is a virtual one. The present disclosure will solve such a problem.

In accordance with one form of the present disclosure, the navigation system preferably includes a notification consignment transmitting section, which transmits notification consignment to the one or more second movable bodies, which have the information indicating a movement characteristic similar to the information indicating the movement characteristic of the first movable body. The second movable body that has received the notification consignment is consigned to notify the required time calculator of the position information. When the second movable body that has received the notification consignment leaves the second route directed to the second point, the notification consignment transmitting section generates the notification consignment such that the second movable body acquires the information indicating movement characteristics of other one or more movable bodies on the second route directed to the second point. The notification consignment transmitting section generates the notification consignment such that the second movable body leaving the second route transmits the notification consignment to a mobile unit having the information indicating a movement characteristic similar to that of the first movable body from among the other one or more movable bodies.

In the above-described configuration, even when the second movable body that receives notification consignment and notifies the required time calculator of position information leaves the second route directed to the second point, consignment of notification of the position information is transmitted to another movable body having information indicating a movement characteristic similar to that of the first movable body. Therefore, since notification consignment can be exchanged among a plurality of movable bodies having movement characteristics similar to that of the first movable body in a relay fashion, it is possible to obtain results similar to results in a case in which the first movable body actually moves along the route.

In accordance with one form of the present disclosure, the required time calculator is preferably configured to predict the first required time period using the position of the first movable body, and the required time calculator is preferably configured to predict the second required time period using the position information notified from the second movable body. Also, the navigation system further preferably includes a display section, which is configured to display a mark indicating a result of comparison between the first required time period and the second required time period on a map image.

As the first movable body moves away from the second movable body, the map tends to be scaled down so as to display their positions simultaneously within one map image, and so a wide-area map is displayed. When the map scale is smaller than the scale specified by the user, the function that should originally guide the route up to the second point may not be exerted. In this respect, in the above-described configuration, marks that can identify comparison results of predicted required time periods are displayed on a map image, and it is thereby possible to notify the user of the difference in the predicted required time periods without changing the scale of the map image.

In accordance with one form of the present disclosure, the storage section preferably stores, as the information indicating the movement characteristic, information indicating at least one of: movable body static information, which is static information related to the first movable body and the second movable body; movable body dynamic information, which is changing information related to the first movable body and the second movable body including an average speed or the number of occupants of the movable bodies; and user information related to the respective users of the first movable body and the second movable body.

In the above-described configuration, the second movable body having a movement characteristic similar to that of the first movable body includes at least one of movable body static information related to the movable body, movable body dynamic information that is changing information related to the movable body including the average speed and the number of occupants of the movable body, and user information related to the user of the movable body. Therefore, by using the position information of the selected movable body, it is possible to obtain results similar to the results in a case in which the first movable body actually moves along the route.

In accordance with one form of the present disclosure, the navigation system preferably includes a movement time calculator, an average movement time acquiring section, and a traveling result evaluation section. The movement time calculator is configured to calculate a movement time for the second movable body from the movement result of the second movable body. The movement time calculator is configured to calculate a movement time for the second movable body for each of a plurality of sections into which the route the second movable body travels is divided. The average movement time acquiring section is configured to acquire an average movement time associated with the section. The traveling result evaluation section is configured to compare a movement time calculated for each section and the average movement time. The traveling result evaluation section is configured to notify the user of the first movable body of a section longer than the average movement time or a section shorter than the average movement time.

In the above-described configuration, notification is made of a section where the actual movement time is longer than the average movement time, or a section where the actual movement time is shorter than the average movement time from the movement results of the second movable body. Therefore, while figuring out which is longer or shorter: the actual required time period required to reach the second point via the first route or the required time period required to reach the second point via the second route, the user of the first movable body can know which section is a factor of delay or a factor of reducing the required time period in the case of passing through the second route.

Other aspects and advantages of the present disclosure will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosure, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

FIG. **1** is a block diagram illustrating a schematic configuration of a navigation system according to a first embodiment;

FIG. **2** is a functional block diagram illustrating functions of the navigation controller of the above-described embodiment;

FIG. **3** is a conceptual diagram illustrating an example of a configuration of tablet information that is notification consignment;

FIG. **4** is a schematic view illustrating an example of exchange of tablet information between the host vehicle and a consignee vehicle;

FIG. **5** is a schematic view illustrating an example of exchange of tablet information between the consignee vehicle and a new consignee vehicle;

FIG. **6** is a schematic view illustrating a display example notifying a required time period for the host vehicle compared to a required time period for a consignee vehicle to reach a destination;

FIG. **7** is a schematic view illustrating a display example notifying a required time period for the host vehicle compared to a required time period for a consignee vehicle to reach a destination;

FIG. **8** is a flowchart illustrating a procedure when the navigation system of the host vehicle according to the above-described embodiment transmits tablet information;

FIG. **9** is a flowchart illustrating a procedure that follows the flowchart shown in FIG. **8**;

FIG. **10** is a flowchart illustrating a procedure when the navigation system of the host vehicle according to the above-described embodiment compares the required time period for the host vehicle with the required time period for a consignee vehicle and provides notice of the comparison result;

FIG. **11** is a schematic view of a navigation system according to a second embodiment, illustrating a situation in which the navigation system exchanges tablet information with a plurality of consignee vehicles;

FIG. **12** is a schematic view illustrating a display example in which the navigation system of the above-described embodiment provides notice of a required time period for the host vehicle compared to a required time period for a consignee vehicle to reach a destination;

FIG. **13** is a schematic view of a navigation system according to a third embodiment, illustrating a display example in which the navigation system provides notice of a required time period for the host vehicle compared to a required time period for a consignee vehicle to reach a destination; and

FIG. **14** is a schematic diagram of a navigation system according to a modification, illustrating an information network including a portable information terminal equipped with a navigation system and a portable information terminal, to which notification of position information is consigned.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

Hereinafter, a navigation system **12** according to a first embodiment will be described. The navigation system **12** according to the present embodiment calculates a first required time period as a required time period for a host vehicle **11**, which is a first movable body, to arrive at a second point from a first point and a second required time period as a required time period for another vehicle, which is a second movable body, to arrive at the second point from the first point after passing through a route different from that of the host vehicle.

As shown in FIG. **1**, the navigation system **12**, which is mounted on the host vehicle **11**, is connected to a position detection section **15** and an indicator direction detection section **16** via a vehicle-mounted network **13**. The position detection section **15** detects the position of the host vehicle **11**, and is provided with at least one of a positioning sensor that receives a signal from a satellite positioning system such as a GPS (global positioning system), an orientation sensor that detects an orientation, a vehicle speed sensor that detects the vehicle speed, and a communication device that receives the position through road-to-vehicle communication or the like.

The indicator direction detection section **16** is a sensor or a computer that detects an indicator direction of the directional indicator operated by a user.

The navigation system **12** is further connected to a vehicle-to-vehicle communication section **17** and a center communication section **18** via the vehicle-mounted network **13**. The vehicle-to-vehicle communication section **17** performs vehicle-to-vehicle communication with another vehicle **110** located within a communication distance via wireless LAN (local area network) of a predetermined standard, for example. The center communication section **18** communicates with an information providing server **101** installed in a center **100** via a public channel or the like.

A human machine interface (HMI) **30**, which receives operation from the user of the host vehicle **11** and broadcasts information to the user, is connected to the navigation system **12**. The HMI **30** outputs information provided by the navigation system **12** and receives a command by the user's input operation. The HMI **30** includes a display as a display section provided in the vicinity of a driver's seat. The HMI **30** may also include at least one of a display section provided on an instrument panel, a head-up display, and a speaker, which outputs sound. The input section that inputs commands is at least one of a touch panel provided on the display, operation buttons provided together on the display, and a speech recognition device or the like.

Next, the configuration of the navigation system **12** will be described. The navigation system **12** is provided with a navigation controller **20**, a map information storage section **21** and a traveling characteristic information storage section **22**. The navigation controller **20** is provided with a calculator and a storage section, and the calculator performs various kinds of control according to programs stored in the storage section. The programs stored in the storage section include a required time period calculation program. This required time period calculation program is a program that consigns, when the host vehicle leaves a preset initial route, notification of position information to another vehicle traveling along the initial route. The calculator of the navigation controller **20** is constructed by ECUs (Electronic Control Units).

The map information storage section **21** stores route search information **23** and map image information **24**. The route search information **23** includes node data, which is information for searching for a route from a place of departure to a destination and related to a node set at an intersection or a branch point, link data related to links set among a plurality of nodes, and road attribute information such as the advancing direction, the number of lanes, the road type or the like. The map image information **24** is image information for drawing a map image on the display, which is included in the HMI **30**.

The traveling characteristic information storage section **22** stores traveling characteristic information **25** as movement characteristic information. The traveling characteristic information **25** is information indicating a traveling characteristic of the host vehicle and includes vehicle static information **26**, vehicle dynamic information **27**, and user information **28**.

The vehicle static information **26** is information indicating a movement characteristic of the host vehicle and is static information related to the host vehicle. The vehicle static information **26** includes not only the vehicle width and the overall length but also vehicle class information such as minivan wagon or sport type. Vehicles having similar vehicle static information **26** tend to have similar required time periods when traveling the same route. For example, when a vehicle and an oncoming vehicle having substantially the same vehicle width pass each other on a narrow road, their required time periods for passing each other are estimated to be similar. Furthermore, when a vehicle turns a corner of a narrow road, since the necessity for reversing the steering direction differs depending on the size of the wheel base, vehicles of the same vehicle class tend to have similar required time periods for passing through such a corner. Moreover, since vehicles of the same vehicle class tend to have the same field of view from the driver's seat, acceleration performance or the like, their required time periods tend to be close to each other over the entire route. The vehicle static information **26** corresponds to movable body static information.

The vehicle dynamic information **27** is information indicating the movement characteristic of the host vehicle and is information that changes depending on the situation. The vehicle dynamic information **27** includes the most recent average speed, the number of occupants or the like. The most recent average speed is a speed obtained by averaging vehicle speeds of the most recent predetermined time period or the most recent predetermined traveling distance. The number of occupants is the number of people riding on the host vehicle, and is the number of people inputted by the user or the number of people calculated based on a detection result of a seat sensor provided on each seat. Vehicles having similar vehicle dynamic information **27** tend to have similar required time periods when traveling the same route. For example, when the most recent average speeds are the same, it is possible to estimate that users have similar operation tendencies, and when the vehicles travel along the same route, they tend to have similar required time periods. When the numbers of occupants are the same, since tendencies of starting moving and stopping are estimated to be similar, when the vehicles travel along the same route, they tend to have similar required time periods. The vehicle dynamic information **27** corresponds to movable body dynamic information.

The user information **28** is information related to the user who drives the host vehicle and has the driving characteristic and the driving skill of the user. The driving characteristic shows tendencies of the user's driving. For example, the driving characteristic shows a driving tendency of keeping the vehicle speed while repeating changes of lanes or a driving tendency of traveling on the same lane without changing lanes. This driving characteristic may be a characteristic learned by the navigation system **12** or a characteristic registered by the user. The driving skill is one determined according to the date of obtaining the license, age or the like. The user information **28** may be stored for each user who drives the host vehicle. Vehicles having similar user information **28** tend to have similar required time periods when traveling the same route. For example, if the drivers have the same driving characteristic or driving skill, since they are estimated to have similar tendencies such as obstacle avoiding behavior, vehicle speed, braking operation, acceleration operation or the like, they tend to have similar required time periods when traveling the same route.

With reference to FIG. **2**, functions of the navigation controller **20** will be described. Each function described below is exerted by the calculator (ECUs) of the navigation controller **20** executing processes according to programs stored in the storage section.

A traveling characteristic learning section **31** acquires a vehicle speed from the vehicle speed sensor, which is part of the position detection section **15** and learns the most recent average speed or a driving characteristic or the like. The learned user traveling characteristic is stored as user information **28** in the traveling characteristic information storage section **22**.

A host vehicle position identification section **32** identifies the host vehicle position based on the vehicle position inputted from the position detection section **15**. A route search section **33** searches for a route from a place of departure to a destination using the host vehicle position inputted from the host vehicle position identification section **32** and the route search information **23**. The found route or the found routes are outputted to the HMI **30** and one of them is set by the user as an initial route.

A separation determining section **34** predicts a traveling direction of the vehicle based on the traveling direction of the initial route inputted from the route search section **33** and a detection signal inputted from the indicator direction detection section **16**. Although the traveling direction along the initial route is a direction in which the vehicle travels straightforward through an intersection ahead of the host vehicle or a branch point, if a detection signal indicating a left turn or a right turn is inputted from the indicator direction detection section **16**, it is determined that the host vehicle is likely to have left the initial route. On the other hand, although the traveling direction along the initial route is a direction corresponding to a left turn at an intersection ahead of the host vehicle or a branch point, if no direction indicating signal has been received from the indicator direction detection section **16** or if an indication for a right turn has been inputted, it is determined that the host vehicle is likely to have left the initial route.

Even when no indicator direction is inputted, the separation determining section **34** determines whether the position of the host vehicle is on the initial route and determines whether the vehicle has actually left the initial route. When the separation determining section **34** determines that the intention of the user's direction indication is a change of lanes, parking on the road, stop at a facility located along the initial route or the like and the position of the host vehicle is on the initial route, the separation determining section **34** determines that the host vehicle is traveling the initial route even after determining that the host vehicle is likely to have left the initial route. The determination as to whether the host vehicle has left the initial route is made based on whether the host vehicle is located on a link of an alternative route, not on a link indicating the initial route or whether the host vehicle has moved away from the initial route by a predetermined distance or more.

When the host vehicle leaves the initial route, a consignee vehicle determining section **35** as a movement characteristic information acquiring section searches for another vehicle storing the same program as the required time period cal-

culation program stored in the host vehicle **11** via a communication controller **36**. The communication controller **36** controls communication between the navigation controller **20** and the vehicle-to-vehicle communication section **17**, and the center communication section **18**. The search for another vehicle by the consignee vehicle determining section **35** is performed mainly through vehicle-to-vehicle communication but may also be performed through communication via the center **100**.

The consignee vehicle determining section **35** selects other vehicles directed toward the same traveling direction as the traveling direction along the initial route from among other vehicles detected by the search and then selects one vehicle from among the selected other vehicles. In selecting one vehicle, the consignee vehicle determining section **35** acquires traveling characteristic information **25** of the host vehicle via the traveling characteristic learning section **31**. The consignee vehicle determining section **35** acquires traveling characteristic information of the other vehicles and route information set in the other vehicles from the selected other vehicle or the selected other vehicles. The consignee vehicle determining section **35** then preferentially selects other vehicles having traveling characteristic information similar to that of the host vehicle from among the other vehicles whose traveling characteristic information and route information have been acquired. When no route is set in the other vehicles, the most recent traveling direction of the other vehicles may be designated as the route information instead of the set route. That is, the consignee vehicle determining section **35** selects another vehicle that satisfies at least one of the following items (a) to (f) as a consignee vehicle.

(a) That the vehicle travels the longest distance in the initial route

(b) That at least one of the vehicle width, the overall length, and the vehicle class is the same as that of the host vehicle

(c) That the difference from the most recent average speed of the host vehicle falls within a predetermined range

(d) That the number of occupants is the same as that of the host vehicle

(e) That the driver's skill is the same as that of the host vehicle

(f) That the driver's driving tendency is the same as that of the host vehicle

Among the items (a) to (f), the item (a) has the highest priority. The priority decreases thereafter in order of the item (b) related to vehicle static information **26**, the items (c), (d) related to vehicle dynamic information **27**, and the items (e), (f) related to user information **28**. The vehicle static information **26** is static information and has high reliability, and therefore has high priority, whereas the vehicle dynamic information **27** and the user information **28** are changing information, and therefore have low priority. Scores are defined for the items (a) to (f) according to the priority. When two or more vehicles are detected, the consignee vehicle determining section **35** sums up scores of the items (a) to (f) satisfied by the other vehicles, calculates the total score, and selects a vehicle having the highest score.

The vehicle selected in this way is designated as a consignee vehicle to which notification of the position information to the navigation system **12** of the host vehicle **11** is consigned. A tablet consigning section **37** as a notification consignment transmitting section transmits tablet information **50**, which is notification consignment of position information, to a consignee vehicle via the communication controller **36**. The tablet information **50** is similar to a so-called tablet block used in railway or the like, and the other vehicle that receives this tablet information **50** hands over the tablet information **50** to a different vehicle when leaving the initial route.

As shown in FIG. **3**, the tablet information **50** transmitted from the host vehicle includes UID **51**, which is a unique ID of the transmission source user of the tablet information **50** or the host vehicle, initial route information **52** indicating the initial route and traveling characteristic information **53** of the host vehicle. The traveling characteristic information **53** is information read from the traveling characteristic information storage section **22** and includes the vehicle static information **26**, the vehicle dynamic information **27**, and the user information **28**.

When direction indication by the user of the host vehicle is intended to be a change of lanes, parking on the street or the like, the separation determining section **34** may determine, after transmitting the tablet information **50**, that the host vehicle does not leave but continues to travel the initial route. In that case, the tablet consigning section **37** sends a request for canceling the tablet information **50** to the destination vehicle. The consignee vehicle that receives the cancel request either discards the received tablet information **50** or returns the tablet information **50**.

A tablet position determining section **38** shown in FIG. **2** determines the position of the consignee vehicle based on the position information received from the consignee vehicle. A required time calculator **39** calculates a required time period for the consignee vehicle to arrive at the destination and a required time period for the host vehicle to arrive at the destination using the remaining distance from the position of the consignee vehicle to the destination and the remaining distance from the position of the host vehicle to the destination. This required time period is calculated by dividing each remaining distance by the average traveling speed or legally prescribed speed or the like stored in the route search information **23**.

A notification section **40** provides notice of which of the required time period for the consignee vehicle to arrive at the destination or the required time period for the host vehicle to arrive at the destination is shorter via the HMI **30**. In this case, the notification section **40** notifies the user of the required time period for the consignee vehicle substituted by the required time period for the host vehicle to travel the initial route. Speech notifying how much the required time period for the route the vehicle actually has traveled is shorter or longer than the required time period of the initial route is outputted from a speaker by saying, for example, "This route precedes the initial route by 10 minutes." Furthermore, results of a comparison between the required time period when the vehicle travels the initial route and the required time period when the vehicle leaves the initial route are displayed on the display in an identifiable manner.

In contrast, when the host vehicle is selected as a consignee vehicle and the navigation system **12** receives the tablet information **50**, the following process is performed. The same procedure upon receiving the tablet information **50** is applied to not only the host vehicle but also other vehicles having the required time period calculation program. A tablet receiving section **41** analyzes the tablet information **50** received via the communication controller **36**. A tablet position transmitting section **42** acquires a UID **51** of the tablet information **50** from the tablet receiving section **41** and transmits the position information of the host vehicle to a vehicle having the UID **51** as the destination. Upon receiving a command from the tablet receiving section **41**, the separation determining section **34** determines

whether the host vehicle has left the route based on the initial route information **52** included in the tablet information **50**.

When the separation determining section **34** determines that the host vehicle selected as a consignee vehicle has left the initial route indicated by the tablet information **50**, the consignee vehicle determining section **35** selects a new consignee vehicle. The method of selecting an consignee vehicle is substantially the same as that in the case where the host vehicle transmits the tablet information **50**, but the method selects a vehicle having traveling characteristic information similar to the traveling characteristic information of the transmission source vehicle of the tablet information **50** instead of selecting a vehicle having traveling characteristic information similar to the traveling characteristic information **25** of the host vehicle. At this time, the consignee vehicle determining section **35** acquires the traveling characteristic information **53** included in the tablet information **50** and also receives the route information and traveling characteristic information from the other vehicle, and newly selects a vehicle having traveling characteristic information similar to the traveling characteristic information **53** of the transmission source vehicle as a consignee vehicle.

When a consignee vehicle is newly selected in this way, the tablet consigning section **37** of the host vehicle transmits the tablet information **50** to the new consignee vehicle, also transmits the tablet information **50** to the transmission source vehicle, and thereby cancels the setting of a consignee vehicle. The setting of a consignee vehicle may also be canceled by discarding the tablet information **50**.

Next, an example of exchange of the tablet information **50** will be described with reference to FIGS. **4** and **5**. Suppose that the host vehicle **11** is traveling from the place of departure to the destination along the initial route.

As shown in FIG. **4**, for example, when it is predicted that, based on operation of the directional indicator of the host vehicle **11** or the like, the host vehicle **11** will leave an initial route **111** and the host vehicle **11** will travel an alternative route **112**, which is different from the initial route **111**, the consignee vehicle determining section **35** searches for the other vehicle **110** storing the required time period calculation program through vehicle-to-vehicle communication and selects an consignee vehicle **115** from among other vehicles **110**. The tablet consigning section **37** transmits the tablet information **50** to the consignee vehicle **115** via the communication controller **36**. The initial route **111**, which the host vehicle **11** has left, corresponds to a second route, and the alternative route **112**, which the host vehicle **11** actually travels, corresponds to a first route.

The consignee vehicle **115**, which has received the tablet information **50**, executes a process according to a required time period calculation program while traveling the initial route **111** of the host vehicle, and thereby transmits position information **55** to the host vehicle **11**, which is the transmission source of the tablet information **50**. The tablet position determining section **38** of the host vehicle **11** receives the position information **55**. The required time calculator **39** of the host vehicle **11** calculates a first required time period for the host vehicle **11** to arrive at a destination **120** and a second required time period for the consignee vehicle **115** to arrive at the destination **120**.

By executing a process according to the required time period calculation program, the consignee vehicle **115** determines whether the consignee vehicle **115** will leave the initial route using the initial route information **52** included in the received tablet information **50**.

As shown in FIG. **5**, when it is predicted, based on, for example, operation of the directional indicator in the consignee vehicle **115**, that the consignee vehicle **115** will leave the initial route **111**, the consignee vehicle **115** searches for other vehicles **110** in the vicinity and selects a vehicle having the same traveling direction as that of the initial route **111** and having traveling characteristic information similar to that of the vehicle (host vehicle **11**) of the transmission source of the tablet information **50** from among the detected other vehicles **110** as a new consignee vehicle **116**.

When the consignee vehicle **116** is newly selected, the tablet information **50** is transferred to the new consignee vehicle from the consignee vehicle **115** predicted to leave the initial route **111**. The new consignee vehicle **116**, which has received the tablet information **50**, transmits the position information **55** to the vehicle (host vehicle **11**) of the transmission source of the tablet information **50**. By enabling the tablet information **50** to be transferred in a relay fashion in this way, it is possible to virtually calculate a third required time period that is a required time period when the host vehicle **11** travels the initial route **111** even when the consignee vehicle **115** leaves the initial route **111**. When selecting a consignee vehicle, since priority is given to the other vehicle **110** having traveling characteristic information similar to that of the host vehicle **11**, which is the transmission source of the tablet information **50**, the required time period for a consignee vehicle to arrive at the destination naturally approximates to the required time period for the host vehicle **11** to arrive at the destination.

Next, a display example using a display **60**, which is part of the HMI **30**, will be described with reference to FIGS. **6** and **7**. The display **60** basically shows a map image **61**, which is an image of a map of areas surrounding the host vehicle, on a scale specified by the user. While the navigation system **12** is conducting route guidance, a host vehicle position mark **63** indicating the host vehicle position and a route display **64** indicating the route that the vehicle is traveling are displayed on the map image **61**. As described above, when the calculation result of the required time period during which a consignee vehicle is set is notified, if the relative distance between the consignee vehicle and the host vehicle increases, the scale cannot but be reduced in order to display both the position of the consignee vehicle and the position of the host vehicle on the screen of the display **60**. When the scale of the map image is made to be smaller than the scale specified by the user and a wide-area map is displayed, it may be difficult to distinguish the road shape in the vicinity of the position of the host vehicle and the traveling direction. Therefore, when the calculation result of the required time period is notified using the map screen, it is desirable to notify the calculation result on a scale specified by the user.

Thus, the notification section **40** displays a mark allows for identification of the result of a comparison between the required time period for the other vehicle and the required time period for the host vehicle, superimposed on the map image.

For example, as shown in FIG. **6**, when the required time period for the host vehicle is shorter than the required time period for the consignee vehicle, the color of the host vehicle position mark **63** displayed on the map image **61** is made to be different from the color of the host vehicle position mark **63** when no comparison is made in the required time period of the route. For example, blue is determined as the color of the host vehicle position mark **63**.

On the other hand, as shown in FIG. **7**, when the required time period for the host vehicle is longer than the required

time period for the consignee vehicle, the color of the host vehicle position mark **63** displayed on the map image **61** is determined to be red, for example, a color different from the color in the case where the required time period for the host vehicle is shorter than the required time period for the consignee vehicle.

In addition, when the required time period for the host vehicle is longer than the required time period for the consignee vehicle, the host vehicle position mark **63** displayed on the map image **61** may be made to blink. By changing the display mode of the host vehicle position mark **63** in this way, it is possible to notify the calculation result of the required time period during which the consignee vehicle is set without changing the scale specified by the user.

Moreover, the scale may be changed to one in which the position of the host vehicle and the position of the consignee vehicle are included within the map display region by the user operating predetermined operation buttons (not shown) provided together with the predetermined operation button **65** and the display **60** displayed superimposed on the map image **61**.

Next, operation of the navigation system **12** will be described with reference to FIGS. **8** to **10**. Suppose the host vehicle **11** equipped with the navigation system **12** is traveling along the initial route found by the route search section **33**.

First, a transmission process of the tablet information **50** to the consignee vehicle will be described with reference to FIG. **8**. The separation determining section **34** of the navigation controller **20** determines whether separation of the host vehicle **11** from the initial route is predicted (step S**1**). When the separation from the initial route is not predicted (step S**1**: NO), the separation determining section **34** determines whether unpredicted separation from the initial route has occurred (step S**10**). The separation determining section **34** determines whether the host vehicle has actually left the initial route by comparing the position of the host vehicle **11** with the initial route irrespective of the presence or absence of an indicator direction by the directional indicator.

Upon determining that there is no unpredicted separation (step S**10**: NO), the separation determining section **34** determines whether the host vehicle has arrived at the destination (step S**11**). When the host vehicle **11** arrives at the destination without leaving the initial route (step S**11**: YES), the tablet information **50** is not transmitted.

When direction indication is performed for a traveling direction different from the initial route or when direction indication for the same traveling direction as that of the initial route is not performed, the separation determining section **34** determines that separation from the initial route is predicted (step S**1**: YES).

When separation from the initial route is predicted (step S**1**: YES) and when unpredicted separation occurs such as when the vehicle turns to the right/left irrespective of the absence of direction indication (step S**10**: YES), the consignee vehicle determining section **35** searches, through vehicle-to-vehicle communication, for one or more vehicles having a required time period calculation program (step S**2**). At this time, the consignee vehicle determining section **35** requests route information and traveling characteristic information from the other vehicles, and the other vehicles that have received this request transmit route information on a route set in the host navigation system and traveling characteristic information to the host vehicle.

The consignee vehicle determining section **35** of the host vehicle determines, from the reception result, whether there is any vehicle that can be set as a consignee vehicle (step S**3**). Upon receiving the route information and the traveling characteristic information, the consignee vehicle determining section **35** determines whether there is any other vehicle having the same traveling direction as the traveling direction of the initial route.

When there is a vehicle that can be set as a consignee vehicle (step S**3**: YES), the consignee vehicle determining section **35** selects a consignee vehicle from among the other vehicles (step S**4**). After selecting a consignee vehicle, the tablet consigning section **37** transmits the tablet information **50** to the vehicle selected as a consignee vehicle (step S**5**). At this time, the tablet consigning section **37** stores the position and the date and time at which the tablet information **50** is transmitted in a storage section.

After transmitting the tablet information **50**, the separation determining section **34** determines, using the position of the host vehicle, whether the host vehicle has left the initial route as predicted (step S**6**). When it is determined in step S**10** that unpredicted separation has occurred, step S**6** may be omitted. When it is determined that the host vehicle has left the initial route as predicted (step S**6**: YES), the transmission process of the tablet information **50** is ended.

Upon determining that the host vehicle has actually traveled along the initial route contrary to the prediction (step S**6**: NO), for example, a case where the direction indication is for a change of lanes or parking on the street, a request for canceling the tablet information **50** already transmitted to a consignee vehicle is transmitted (step S**7**). The consignee vehicle either returns the tablet information **50** or discards the tablet information **50**. After canceling the tablet information **50**, the flow returns to step S**1** to determine whether or not to leave the initial route.

Next, with reference to FIG. **9**, a case will be described in which it is predicted that the host vehicle **11** will leave the initial route (step S**1**: YES) or a case where there is no other vehicle that can be set as a consignee vehicle in the vicinity of the host vehicle **11** despite the fact that unpredicted separation from the initial route has occurred (step S**10**: YES).

When it is predicted that the host vehicle **11** will leave the initial route or when an unpredicted separation from the initial route has occurred, if the consignee vehicle determining section **35** determines that there is no other vehicle that can be set as a consignee vehicle (step S**3**: NO in FIG. **8**), the consignee vehicle determining section **35** sets a virtual vehicle that moves from the current position of the host vehicle **11** at the average speed (step S**20**). The average speed is stored in the route search information **23** in association with a link or the like or is acquired from the information providing server **101** and associated with the current position.

While setting the virtual vehicle moving at the average speed, the consignee vehicle determining section **35** determines whether there is any vehicle that can be set as a consignee vehicle in the vicinity of the virtual vehicle (step S**21**). At this time, when the host vehicle is located apart from the virtual vehicle by a distance greater than a vehicle-to-vehicle communicable distance, the consignee vehicle determining section **35** searches for a vehicle that can be set as a consignee vehicle through communication via the center **100** or the like.

Upon determining that there are other vehicles that can be set as consignee vehicles in the vicinity of the virtual vehicle (step S**21**: YES), the consignee vehicle determining section **35** selects a consignee vehicle from among those other vehicles (step S**22**) and transmits the tablet information **50**

to the selected consignee vehicle (step S23). The tablet information 50 is transmitted mainly through communication via the center 100.

After transmitting the tablet information 50, the separation determining section 34 determines, using the position of the host vehicle, whether the host vehicle has left the initial route as predicted (step S24). Upon determining that the host vehicle has left the initial route as predicted (step S24: YES), the separation determining section 34 ends the transmission process on the tablet information 50.

When the separation determining section 34 determines that the host vehicle has traveled along the initial route contrary to the prediction (step S24: NO), the tablet consigning section 37 transmits a request for canceling the tablet information 50 already transmitted to the consignee vehicle (step S26). The consignee vehicle either returns the tablet information 50 or discards the tablet information 50.

When the tablet information 50 is canceled (step S26) and when there is no other vehicle that can be a consignee vehicle in the vicinity of the virtual vehicle (step S21: NO), a vehicle that can be a consignee vehicle is searched for (step S21) while a virtual vehicle that moves at the average speed is being set (step S20). These steps S20 to S26 end when the host vehicle 11 arrives at the destination. That is, when the host vehicle 11 arrives at the destination without any vehicle that can be set as a consignee vehicle in the vicinity of the virtual vehicle, the process of transmitting the tablet information 50 is ended.

The host vehicle 11 itself can become the transmission source of the tablet information 50 and at the same time can also function as a consignee vehicle for other vehicles. When the host vehicle 11 is selected as a consignee vehicle, it is determined whether the host vehicle 11 will leave the initial route indicated by the initial route information 52 included in the tablet information 50 while transmitting position information to the vehicle that is the transmission source of the tablet information 50.

Next, a comparison of required time periods of the route and the notification process thereof will be described with reference to FIG. 10. The tablet position determining section 38 of the navigation system 12 of the host vehicle determines whether position information has been received from the consignee vehicle (step S30). Upon determining that the position information has been received from the consignee vehicle (step S30: YES), the required time calculator 39 calculates the remaining distance from the position of the consignee vehicle to the destination, divides the remaining distance by the average speed and predicts a required time period for the consignee vehicle to arrive at the destination (step S31).

Furthermore, the required time calculator 39 calculates the remaining distance from the position of the host vehicle to the destination, divides the remaining distance by the average speed, and predicts a required time period for the host vehicle to arrive at the destination (step S32).

The required time calculator 39 predicts, from the required time period for the host vehicle and the required time period for the consignee vehicle, the difference therebetween (step S33). Based on the difference in the required time periods, the notification section 40 provides notice of it via the HMI 30 (step S34). At this time, the notification section 40 outputs speech like "This route precedes the initial route by 10 minutes" from the speaker or changes the display mode of the host vehicle position mark 63 displayed on the screen of the display 60.

The tablet position determining section 38 determines whether the consignee vehicle has arrived at the destination (step S35). Also when there is no other vehicle that can be set as a consignee vehicle and a virtual vehicle is set, the tablet position determining section 38 determines whether the virtual vehicle has arrived at the destination. Whether the consignee vehicle has arrived at the destination can also be determined from the position of the consignee vehicle, but if the tablet information 50 is transmitted from the consignee vehicle when the consignee vehicle arrives at the destination, whether the consignee vehicle has arrived at the destination can also be determined based on the presence or absence of the received tablet information 50. Upon determining that the consignee vehicle or virtual vehicle has arrived at the destination (step S35: YES), if the host vehicle is traveling the initial route, the fact that the vehicle has arrived at the destination or a required time period when the vehicle travels the initial route is notified (step S39).

Upon determining that the consignee vehicle has not arrived at the destination (step S35: NO), the host vehicle position identification section 32 determines whether the host vehicle has arrived at the destination (step S36). When the host vehicle has not arrived at the destination (step S36: NO), the flow returns to step 30 to determine whether position information has been received from the consignee vehicle.

Upon determining that the host vehicle has arrived at the destination (step S36: YES), the required time calculator 39 performs a guidance end process (step S38), and ends the process. That is, when the consignee vehicle arrives at the destination before the host vehicle 11, the host vehicle 11 can receive the tablet information 50 transmitted from the consignee vehicle, whereas when the host vehicle 11 arrives at the destination first, the host vehicle 11 may not be able to receive the tablet information 50 transmitted from the consignee vehicle depending on the condition of the navigation system 12. Therefore, returning of the tablet information 50 from the consignee vehicle may be stopped or the navigation system 12 may be maintained, even after arriving at the destination, in a standby state ready to receive the tablet information 50. By maintaining the navigation system 12 in the standby state, even when the consignee vehicle arrives at the destination after the host vehicle, if the navigation system 12 is restarted, it is possible to compare the required time period when the host vehicle leaves the initial route and the required time period when the host vehicle does not leave the initial route.

On the other hand, when the tablet position determining section 38 determines that no position information has been received from the consignee vehicle (step S30: NO), the required time calculator 39 predicts a required time period for the virtual vehicle (step S40). The required time calculator 39 predicts a required time period for the host vehicle to arrive at the destination (step S41), and also predicts, from the required time period for the host vehicle and the required time period for the virtual vehicle, the difference therebetween (step S42). The notification section 40 provides notice of the difference in the required time periods via the HMI 30 (step S34).

By causing the setting of consignee vehicles to continue in a relay fashion in this way, even when a consignee vehicle leaves the initial route set in the host vehicle, it is possible to virtually calculate a required time period when the host vehicle travels the initial route.

When selecting a consignee vehicle, vehicles having traveling characteristic information similar to the traveling characteristic information of the host vehicle are preferentially designated as consignee vehicles, and it is therefore

possible to obtain a required time period close to one in a case in which the host vehicle actually travels the initial route.

As described above, the navigation system according to the present embodiment achieves the following advantages.

(1) Position information is acquired preferentially from other vehicles having traveling characteristic information similar to that of the host vehicle from among one or more vehicles that pass through a point at which the host vehicle leaves the initial route and travel toward the direction of the initial route. That is, this position information reflects a traveling characteristic similar to that of the host vehicle and also reflects a traffic situation or the like of the initial route. Therefore, by calculating a required time period for the vehicle to arrive at the destination using this position information, it is possible to obtain a result similar to that in a case in which the host vehicle actually moves along the initial route. Therefore, the user can determine the appropriateness of an alternative route selected by the user through a comparison between the actually required time period for the vehicle to arrive at the destination along the alternative route and the required time period virtually calculated regarding the initial route.

(2) Even when another vehicle that receives the tablet information **50**, which is notification consignment, and notifies the required time calculator **39** of the position information leaves the initial route directed to the destination, the tablet information **50** is transmitted to another vehicle having traveling characteristic information similar to that of the host vehicle. Therefore, it is possible to exchange the tablet information **50** in a relay fashion among other vehicles having traveling characteristics similar to that of the host vehicle, and it is thereby possible to obtain results similar to results in a case in which the host vehicle actually moves along the route.

(3) As the host vehicle moves away from a consignee vehicle, the scale of the map tends to decrease to display their positions simultaneously within one map image, and a wide-area map needs to be displayed. When the scale of the map is smaller than the scale specified by the user, the function that should originally guide the route up to the destination may not be performed. In this respect, the above-described embodiment displays, on the map image, the host vehicle position mark **63**, which allows comparison results of predicted required time periods to be identified and can thereby notify the user of the difference in the predicted required time periods without changing the scale of the map image.

(4) The traveling characteristic information **25** includes vehicle static information **26**, which is static information related to the host vehicle, vehicle dynamic information **27**, which is changing information related to the host vehicle including the most recent average speed and the number of occupants, and user information **28**, which is information related to the user who drives the host vehicle. Thus, by using position information of the consignee vehicle having traveling characteristic information similar to the traveling characteristic information **25** of the host vehicle, it is possible to obtain results similar to results in a case in which the host vehicle actually moves along the route.

Second Embodiment

A navigation system according to a second embodiment will now be described. The differences from the first embodiment will be mainly discussed. The basic configuration of the navigation system of the present embodiment is the same as that of the first embodiment, and redundant descriptions will be omitted.

The navigation system according to the present embodiment is different from the navigation system according to the first embodiment in that a comparison is made among required time periods on a plurality of routes, which are routes from a first point to a second point and are found under different conditions.

The route search section **33** of the navigation controller **20** searches for the route from the place of departure to the destination under different conditions. Examples of the search conditions include a traveling distance, type of road such as a general road or expressway, tolls, the widths of roads, presence or absence of congestion or crowding, ease of driving. The route search section **33** outputs the search result to the HMI **30**. When a plurality of routes is found, the user selects one route from among the routes. Once the user selects the route, the route search section **33** outputs a map image or speech via the HMI **30** and guides the selected route.

As shown in FIG. **11**, the consignee vehicle determining section **35** selects, as consignee vehicles **117** and **118**, other vehicles **110** having the same traveling directions as the traveling directions of alternative routes **112** and **113** other than an initial route **111** selected by the user. In selecting consignee vehicles, vehicles are preferentially selected that have traveling characteristics similar to that of the host vehicle. The time at which a consignee vehicle is selected may be the time at which the host vehicle **11** is located in the vicinity of a branch point **122** where the initial route **111** is branched into alternative routes **112** and **113**. In this case, before and after or when the host vehicle **11** arrives at the branch point **122**, the navigation system **12** of the host vehicle **11** selects a consignee vehicle from among other vehicles that pass through the branch point **122**. The time at which a consignee vehicle is selected may also be the time at which the host vehicle **11** is located in the vicinity of the place of departure **121**.

When a consignee vehicle traveling an alternative route is set, the required time calculator **39** of the host vehicle acquires position information from the consignee vehicle and calculates a required time period for the vehicle to arrive at the destination. Furthermore, the required time calculator **39** calculates a required time period for the host vehicle to arrive at the destination.

As shown in FIG. **12**, when required time periods of a plurality of consignee vehicles are calculated, a ranking **67** of the host vehicle is displayed next to the host vehicle position mark **63** drawn superimposed on the map image **61** displayed on the display **60**. The ranking is assigned to the host vehicle and consignee vehicles in ascending order of required time periods.

When a plurality of routes is found in this way, the user can consider whether the selected route is appropriate by virtually calculating required time periods in a case in which the host vehicle travels routes other than the route selected by the user.

In addition to the above described advantages (2) to (4), the navigation system of the present embodiment achieves the following advantages.

(5) Position information is acquired preferentially from vehicles having traveling characteristic information similar to that of the host vehicle from among one or more vehicles that have passed through the place of departure in the same way as the host vehicle or one or more vehicles that have passed through a branch point from which a plurality of

routes is branched from the place of departure to the destination in the same way as the host vehicle. That is, this position information reflects traveling characteristics similar to that of the host vehicle and also reflects traffic situations or the like of routes other than the route selected by the user. Therefore, by calculating the required time period for the vehicle to arrive at the destination using this position information, it is possible to obtain results similar to results in a case in which the host vehicle actually moves along the route. Therefore, the user can determine the appropriateness of the route selected by the user through a comparison between the required time period for the vehicle to actually arrive at the destination and the virtually calculated required time period.

Third Embodiment

A navigation system according to a third embodiment will now be described. The differences from the first embodiment will be mainly discussed. The basic configuration of the navigation system of the present embodiment is the same as that of the first embodiment, and redundant descriptions will be omitted.

The navigation system of the present embodiment is different from the navigation system according to the first embodiment in that the navigation system notifies the user of the host vehicle **11** of, from among movement time of sections obtained by dividing a route along which a consignee vehicle, which is a second movable body, passes into a plurality of sections, a section longer than the average movement time period or a section shorter than the average movement time period associated with the sections.

The required time calculator **39** of the navigation controller **20** functions as a movement time period calculator, the average movement time acquiring section, and a traveling result evaluation section. This required time calculator **39** calculates a movement time for a consignee vehicle for each of the sections into which the initial route is divided from the traveling result of the consignee vehicle. The traveling result of the consignee vehicle is position information notified from the consignee vehicle. The sections into which the initial route is divided may be sections centered on not only links but also nodes or may be sections obtained by dividing the initial route into equal intervals. When the sections are set as sections centered on nodes, dwelling time periods at intersections or branch points associated with the nodes are calculated as movement time, for example.

For example, at time at which the consignee vehicle arrives at the destination, the required time calculator **39** acquires the average movement time for each section included in the route search information **23** stored in the map information storage section **21** or the average movement time for each section registered in the information providing server **101**. The required time calculator **39** compares the calculated movement time and the acquired average movement time for each section, and searches for at least one of a section in which the calculated movement time is shorter than the average movement time and a section in which the calculated movement time is longer than the average movement time. At this time, when the consignee vehicle arrives at the destination earlier than the host vehicle, a section in which the calculated movement time is shorter than the average movement time may be searched for in order to notify the user of which section becomes a factor of advancing the required time period. When the consignee vehicle arrives at the destination later than the host vehicle, a section in which the calculated movement time is longer than the average movement time may be searched for in order to notify the user of which section becomes a factor of delay. Alternatively, irrespective of whether arrival of the consignee vehicle is earlier or later than the host vehicle, both sections may be searched for. The section detected in this search is notified to the user of the host vehicle **11** by the notification section **40**.

FIG. **13** shows an example in which the screen of the display **60** displays both a section in which the calculated movement time is shorter than the average movement time and a section in which the calculated movement time is longer than the average movement time. This route evaluation screen **68** is a screen displayed aside from the map image illustrating the vicinity of the host vehicle. The route evaluation screen **68** displays a short-time section **70**, in which the movement time is shorter than the average movement time, and a long-time section **71**, in which the movement time is longer than the average movement time of the initial route **111**, in different display modes.

Alternatively, the notification section **40** may output speech like "there is a delay on the initial route, or Route 1" from the speaker, which is part of the HMI **30**. Alternatively, the notification section **40** may also show a guide display like "there is a delay on initial route, or Route 1" superimposed on the map image.

When the host vehicle arrives at the destination earlier than the consignee vehicle and the guidance of the navigation system **12** ends before the consignee vehicle arrives at the destination, the navigation system **12** remains in a standby state without shutting down to continue receiving position information from the consignee vehicle and thereby calculates a movement time based on a traveling result. Alternatively, when the information providing server **101** receives position information from the consignee vehicle, stores the position information in the storage section and the navigation system **12** starts, the information providing server **101** may transmit the position information **55** to the navigation system **12**.

In addition to the above described advantages (1) to (4), the navigation system of the present embodiment achieves the following advantage.

(6) Based on the movement result of the consignee vehicle, the user is notified of a section in which the actual movement time is longer than the average movement time or a section in which the actual movement time is shorter than the average movement time. Therefore, the user of the host vehicle can know, by figuring out which of the actual required time period for the user to arrive at the destination or the required time period for the same user to arrive at the destination passing through an alternative route is longer or shorter, which section becomes a factor of delay or a factor of advancing the required time period when passing through the alternative route.

Other Embodiments

The above described embodiments may be modified as follows.

The navigation system **12** may calculate a required time period when returning to the initial route after going through a facility or the like along the initial route or a required time period when returning to the initial route without going through any facility or the like. For example, when the host vehicle goes through a service area or a parking area on an expressway, the separation determining section **34** of the navigation system **12** assumes that the host vehicle has

temporarily leaved the initial route. The consignee vehicle determining section **35** sets a vehicle having a traveling characteristic similar to that of the host vehicle from among one or more vehicles traveling the initial route without going through the service area or parking area as a consignee vehicle. When the consignee vehicle goes through a facility along the initial route, the consignee vehicle transmits the tablet information **50** to another vehicle and designates the new vehicle as a consignee vehicle. The required time calculator **39** receives position information from the consignee vehicle and calculates a required time period for the host vehicle to arrive at a destination after going through a facility and a required time period for the host vehicle to travel the initial route without going through the facility or the like. The notification section **40** provides notice of those required time periods. This allows the user to compare the required time period required when going through a facility and the required time period without going through the facility or the like.

When selecting a consignee vehicle, the consignee vehicle determining section **35** may select a plurality of vehicles as consignee vehicles. When two or more vehicles are selected as consignee vehicles, the host vehicle **11** acquires position information from those consignee vehicles **115**. The required time calculator **39** of the host vehicle **11** calculates a required time period when the host vehicle **11** travels the initial route using, of the consignee vehicles **115**, the position of the first consignee vehicle, the position of a following consignee vehicle and an intermediate position or calculates a required time period when the host vehicle travels the initial route using the position of the first consignee vehicle. When a plurality of vehicles is selected as consignee vehicles in this way, even if some of them leave the initial route, it is possible to calculate the required time period using the positions of the remaining consignee vehicles.

The first point, which is the starting point to compare required time periods of a route, is assumed to be a point at which the vehicle leaves the initial route according to the first embodiment and is assumed to be a place of departure of the route according to the second embodiment. In addition, the first point may be any given point set by the user.

In the above-described embodiments, the second point, which becomes an end point to compare required time periods of a route, is assumed to be a destination. In addition, the second point may be a merging point between the route the host vehicle is traveling and the route the consignee vehicle is traveling or any given point set by the user.

In the above-described embodiments, the traveling characteristic information **25** is assumed to be information including both a characteristic of a vehicle and a characteristic of the user who drives the vehicle, but the traveling characteristic information **25** may include at least one of the characteristic of a vehicle and the characteristic of the user who drives the vehicle.

In the above-described respective embodiments, priority is set in each item indicating the characteristic of the vehicle and the characteristic of the user, but priority does not necessarily need to be set. For example, of the one or more vehicles designated as consignee vehicles, vehicles satisfying most items may be designated as consignee vehicles.

Regarding whether the host vehicle has left the initial route, it is possible to determine whether the host vehicle has left the initial route by subjecting image data picked up by a vehicle-mounted camera to image processing using a known method.

When the host vehicle **11** is temporarily parked at a facility such as a service area or a parking area along the route, a parking time period may be counted and the parking time period may be subtracted from a required time period for the host vehicle **11** to arrive at the destination.

In the above-described respective embodiments, vehicle-to-vehicle communication is used when the tablet information **50** is exchanged if the communication distance is relatively short, but wireless communication may also be performed via a transmitter installed on a roadside or a server at the center.

As shown in FIG. **14**, the movable body may be a portable information terminal **200** carried by a user. In this case, the movement characteristic information indicates a tendency of walking or the age or the like of the user who owns the portable information terminal. The tendency of walking includes a waking speed, tendency of preferring sidewalks along a main road or tendency of preferring narrow streets. A required time period calculation program is stored and an initial route from a first point to a second point are set in the portable information terminal **200**. When the user leaves this initial route, the same required time period calculation program is stored and portable information terminal **201** owned by another user walking along the initial route is searched for. The portable information terminal **201** is searched for using wireless communication carried out between the portable information terminals **200** and **201** or communication with the information providing server **101** connected via a network **203** of a base station **202** and a public channel or the like. The tablet information **50** is transmitted to the portable information terminal **201** having movement characteristic information similar to that of the user out of the detected one or more portable information terminals **201**. The portable information terminal **201** that has received the tablet information **50** transmits position information **55** to the portable information terminal **200**, which is the transmission source of the tablet information **50**. Alternatively, the portable information terminal **200** may be owned by the user who moves from the first point to the second point using means of transportation such as railroad. In this case, the movement characteristic information indicates means of transportation or the like the user owning the portable information terminal frequently uses. The portable information terminal **200** stores a required time period calculation program and an initial route from a first point to a second point including a movement section of the means of transportation is set therein. By this means, the user can appropriately determine the appropriateness of the route selected by the user through a comparison between the required time period required to arrive at the second point and a virtually calculated required time period.

Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

The invention claimed is:

1. A navigation system capable of acquiring a first required time period and a second required time period, wherein the first required time period is a time period required for a first movable body to arrive at a second point from a first point via a first route and the second required time period is a time period required for a second movable body moving along a second route different from the first movable body to arrive at the second point from the first point, the navigation system comprising:

a storage section, which stores information indicating respective movement characteristics of the first movable body and the second movable body, wherein the information is defined in advance and the movement characteristics are classified by one or more factors that affect an arrival time when the first movable body and the second movable body travel an identical route;

a movement characteristic information acquiring section configured to acquire the information indicating the movement characteristics of the first movable body and the information indicating the movement characteristics of the second movable body from the storage section; and

a required time calculator, which calculates a third required time period which is a virtually required time period when the first movable body is assumed to arrive at the second point after movement the second route, which is different from the first route, along which the first movable body actually has moved, wherein

the second movable body, which has passed through the first point as in the case of the first movable body, is one or more second movable bodies,

the required time calculator is configured to preferentially acquire position information from the second movable body having the information indicating a movement characteristic similar to the information indicating the movement characteristic of the first movable body from among the one or more second movable bodies, and

the required time calculator is configured to calculate the third required time period using the acquired position information.

2. The navigation system according to claim **1**, further comprising a notification consignment transmitting section, which transmits notification consignment to the one or more second movable bodies, which have the information indicating a movement characteristic similar to the information indicating the movement characteristic of the first movable body, wherein

the second movable body that has received the notification consignment is consigned to notify the required time calculator of the position information,

when the second movable body that has received the notification consignment leaves the second route directed to the second point, the notification consignment transmitting section generates the notification consignment such that the second movable body acquires the information indicating movement characteristics of other one or more movable bodies on the second route directed to the second point, and

the notification consignment transmitting section generates the notification consignment such that the second movable body leaving the second route transmits the notification consignment to a mobile unit having the information indicating a movement characteristic similar to that of the first movable body from among the other one or more movable bodies.

3. The navigation system according to claim **1**, wherein

the required time calculator is configured to predict the first required time period using the position of the first movable body,

the required time calculator is configured to predict the second required time period using the position information notified from the second movable body, and

the navigation system further comprises a display section, which is configured to display a mark indicating a result of comparison between the first required time period and the second required time period on a map image.

4. The navigation system according to claim **1**, wherein the storage section stores, as the information indicating the movement characteristic, information indicating at least one of:

movable body static information, which is static information related to the first movable body and the second movable body;

movable body dynamic information, which is changing information related to the first movable body and the second movable body including an average speed or the number of occupants of the movable bodies; and

user information related to the respective users of the first movable body and the second movable body.

5. The navigation system according to claim **1**, further comprising:

a movement time calculator, which is configured to calculate a movement time for the second movable body from the movement result of the second movable body, wherein the movement time calculator is configured to calculate a movement time for the second movable body for each of a plurality of sections into which the route the second movable body travels is divided;

an average movement time acquiring section configured to acquire an average movement time associated with the section; and

a traveling result evaluation section configured to compare a movement time calculated for each section and the average movement time, wherein the traveling result evaluation section is configured to notify the user of the first movable body of a section longer than the average movement time or a section shorter than the average movement time.

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